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Exploring the relationship between cognition and self-reported pain in residents of homes for the elderly

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ABSTRACT

Background: Pain poses a major problem in older adults, specifically for those living in homes for the elderly. Previous research indicates that the presence of pain may be associated with changes in cognitive functions. It is unclear, however, how the reported experience of pain relates to cognitive functioning in elderly people with chronic pain. The present study was intended to examine the relationship between clinical pain experience and neuropsychological status in residents of homes for the elderly.

Methods: Forty-one residents suffering from arthritis or arthrosis completed tests measuring memory, processing speed, and executive function. The sensory-discriminative and the affective-motivational aspects of clinical pain were measured.

Results: Performance on executive function tests was positively related to self-reported pain experience. No relationship was observed between pain and memory or processing speed performance.

Conclusion: The present study shows that executive functioning is related to the severity of subjectively reported pain. Possible explanations for this association are discussed.

Key words: chronic pain, aging, executive function, processing speed, memory

Introduction

Painful conditions are common in elderly people (Horgas and Elliott, 2004) and the experience of pain is related to several factors, such as etiology and comorbidity. More recently, attention has been directed towards cognitive factors. Because both pain and cognitive processes demand attention (Eccleston and Crombez, 1999), it may be surmised that the co-occurrence of these two elements induces competition between attentional resources. Indeed, it has been reported that the experience of pain is reduced when subjects engage in demanding cognitive tasks (Valet *et al.*, 2004). One possible explanation is that the resources dedicated to the cognitive task are no longer available for the processing of pain. On the other hand, chronic pain patients have been shown to demonstrate reduced cognitive abilities: they have fewer resources available for cognitive processing as attention is committed to the continuous perception of pain. Studies have revealed decreased cognitive performance in chronic pain patients (Harman and Ruyak, 2005) and an improvement in cognitive functions following pain relief (Tassain *et al.*, 2003). Cognitive domains known to be associated with pain include speed of processing (Harman and Ruyak, 2005), executive function (e.g. Karp *et al.*, 2006), and memory (Grisart *et al.*, 2007). An implication might be that as the level of clinical pain increases, a decrease in cognitive functions is observed. This suggestion is supported by the study of Weiner *et al.* (2006), who showed an inverse relationship between pain severity and several cognitive functions, including attention, visuo-spatial skills, mental flexibility and manual dexterity.

However, studies of the relationship between cognition and pain are limited in that they included middle-aged or relatively young older adults, but not very old people aged 85 years or more. This latter

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population is characterised by more pronounced changes in brain structure, such as atrophy of the prefrontal cortex and the medial temporal lobe, which are part of the aging process (Jack *et al.*, 1998; Raz *et al.*, 1997). As these brain structures are involved in both pain experience and cognitive functions (Scherder *et al.*, 2003), an altered relationship between pain and cognitive functioning as a result of these changes can be anticipated. For example, a previous animal experimental study indicated that memory impairment in mice related to a decrease in pain sensitivity (Pickering *et al.*, 2004). Based on this observation, a *positive* relationship between cognitive functions and pain experience is to be expected.

Finally, when examining pain experience, it is important to note the difference between the sensory-discriminative and the affective-motivational components of pain. Theoretically, these different aspects are processed by two systems, the lateral and medial pathways respectively (Vogt and Sikes, 2000). The lateral pathway processes the sensory-discriminative aspects, whereas the medial pathway processes, among others, the affective- motivational components. Key brain structures involved in processes of the medial pathway include the prefrontal cortex and anterior cingulate cortex, areas that are also known to be involved in cognitive processes such as executive function (Nebel *et al.*, 2005; Lie *et al.*, 2006). These brain structures are much less involved in processes of the lateral pathway. As such, the relationship between cognitive functions and pain experience may be strongest for the affective-motivational components of pain.

The aim of the present study is to explore the relationship between cognitive performance and pain experience in residents of homes for the elderly with a chronic painful condition. Neuropsychological tests measuring memory, processing speed and executive function were administered and both pain intensity, hypothesized to reflect the lateral pain pathway, and pain affect, representing the medial pathway, were measured. If pain reduces attentional resources, a negative relationship between pain and cognition is to be expected. However, if cognitive performance is viewed as an indicator of brain functioning, a positive relationship with pain may be noted.

Methods

Subjects

Recruitment of participants was accomplished through collaboration with homes for the elderly in Amsterdam, the Netherlands. The selection procedure of subjects was as follows: medical records from residents were screened to select subjects suffering from arthrosis or arthritis. Exclusion criteria were: a history of neurodegenerative disease (e.g. dementia, Parkinson's disease), stroke, transient ischemic attack, alcohol or other substance abuse, thyroid disease, and psychiatric disease. Use of nonsteroidal anti-inflammatory drugs and/or other analgesic medication was deduced from medical records. The Mini-mental State Examination (MMSE) (Folstein *et al.*, 1975) was used as a screening instrument to exclude residents with severe cognitive impairment: a score of ≥ 24 was required for participation. Education was measured with an ordinal scale ranging from 1 (incomplete primary school) to 7 (university) (Heslinga *et al.*, 1983). The Symptom Checklist-90 (SCL-90) (Arrindell and Ettema, 1986) was applied to assess depressive symptoms.

Table 1. Subject characteristics ($N = 41$)

VARIABLE	
Age (mean ± SD)	84.6 (5.0)
Gender (% male)	26.8
Analgesic medication (% users)	56.1
MMSE (mean ± SD)	27.0 (1.7)
Depressive symptoms (mean ± SD)	26.1 (8.0)

MMSE: Mini-mental State Examination.

The chronic pain group comprised 43 residents suffering from arthrosis/arthritis. One subject did not complete the questionnaire regarding depressive symptoms, and an additional subject did not complete a major part of the cognitive tests. Both subjects were therefore excluded from further analyses. In cases of occasional missing data with regard to cognitive tests ($n = 7$), the tests that were completed were used to calculate the specific cognitive domain. Subject characteristics are presented in Table 1. This study was approved by the local medical ethics committee. All subjects gave informed consent.

Pain assessment

Both pain intensity and pain unpleasantness (i.e. pain affect) were measured. Two visual rating scales, the Colored Analogue Scale (CAS) (McGrath *et al.*, 1996) and the Faces Pain Scale (FPS) (Bieri *et al.*, 1990), were administered to assess the sensory-discriminative aspects of pain. The CAS and the Number of Words Chosen-Affective (NWC-A) (van der Kloot *et al.*, 1995) were applied to measure the affective-motivational aspects of pain. Previous investigations showed full comprehension of these visual analogue scales by elderly patients without dementia (Scherder and Bouma, 2000), implying that they are very suitable for pain assessment in this population.

Patients were instructed to rate both the pain intensity and the unpleasantness of the pain from which they suffered. To obtain a more reliable indication of pain experience, and to reduce the possibility that a short moment of acute pain skewed the ratings, pain was measured twice, with an approximately four-week interval between both assessments. An average pain score was calculated from these ratings for each pain scale. Using standardized z-scores, separate pain intensity and pain unpleasantness domain scores were calculated. By calculating z-scores, a composite score consisting of separate pain ratings can be created.

Cognitive tests

The participants performed tests measuring memory, processing speed and executive functions. Memory tests included the 15-word list test (Saan and Deelman, 1986), which is a Dutch version of the Auditory Verbal Learning Test, and the Digit Span Forward Test (Wechsler, 1987), both measuring verbal episodic memory. In addition, the Pattern Recognition Memory of the Cambridge Neuropsychological Test Automated Battery (CANTAB) was administered, as a test of visual recognition memory.

Processing speed tests consisted of the Stroop (Stroop, 1935) Word (W) and Color (C) cards, measuring reading and color naming speed. The Trail Making Test (TMT) (Reitan, 1958) part A was also undertaken as a measure of processing speed.

Finally, the following executive function tests were administered: the Spatial Working Memory test (CANTAB), measuring spatial working memory, the TMT part B (Reitan, 1958), reflecting flexibility performance, and the Stroop (Stroop, 1935) C/W card as a measure of inhibition performance. With regard to the TMT B, completion time of part B corrected for part A (TMT-B/TMT-A) was measured. For the Stroop test, an interference score was calculated using the following formula: interference = Stroop C/W – [(C*W)/(C+W)].

For each cognitive domain, a single domain score was calculated by means of standardized z-scores (mean/standard deviation), resulting in three variables (executive function, memory and speed of processing). By calculating z-scores, a composite score consisting of separate cognitive tests can be created. Scores were adjusted so that a higher value always represented better performance.

Statistical analysis

All analyses were performed using SPSS version 14.0 (SPSS, Inc., Chicago, IL). Blom transformations were used to ascertain normality of all variables. Correlations were calculated to examine possible confounding effects of age, education and depressive symptoms on the relationship between pain and cognition. Possible confounding effects of gender and use of analgesics were examined using Mann-Whitney U tests.

In order to examine the hypothesis that an increase in pain experience demands more attention and therefore relates to poorer performance on tests of memory, processing speed and executive functions, correlations were calculated between the pain and cognitive outcome variables. Secondly, multiple linear regression analyses with a stepwise selection criterion were performed to examine possible unique relationships between the cognitive domains and pain experience. Significance for entry was set at $p < 0.05$. These analyses were run separately for the pain intensity and the pain unpleasantness scores.

Results

Pain intensity

A significant positive correlation was observed between pain intensity and depressive symptoms ($r = 0.322$, $p < 0.05$) (Table 2). Furthermore, use of analgesics was a positive predictor of pain intensity ($Z = -2.746$, $p < 0.01$). However, as neither use of analgesics nor depressive symptoms was related to any of the cognitive domains, these factors are unlikely to mediate (part of) the relationship between pain and cognition. Similarly, age correlated with processing speed ($r = -0.337$, $p < 0.05$) and memory ($r = -0.395$, $p < 0.05$), but not with pain intensity. An equal observation was made with regard to education, which was related to processing speed ($r = 0.323$, $p < 0.05$), but not to pain. Finally, type of analgesic medication was classified as either opioids or non-opioids as the former may disrupt cognitive functions; again, however, no association with cognitive functions was observed. On account of this, none of these variables was controlled for.

In considering pain as demanding attention, we expected higher levels of pain intensity to relate inversely to performance on all cognitive domains. This was not observed: the only significant correlation that emerged was a *positive* relationship between pain intensity and executive functions ($r = 0.474$, $p < 0.01$). The correlations between pain intensity and memory ($r = -0.101$, $p = 0.53$) and between pain intensity and processing speed ($r = -0.160$, $p = 0.32$) were not significant. This unique relationship was confirmed with the regression analyses: executive function entered as

Table 2. Associations between cognition, pain experience and possible confounders

VARIABLE	PAIN INTENSITY	PAIN UNPLEASANTNESS	MEMORY	PROCESSING SPEED	EXECUTIVE FUNCTIONS
Age	−0.026	−0.215	−0.395*	−0.337*	−0.197
Gender	−0.397	−0.324	−1.780	−1.324	−1.736
Analgesic medication	−2.746**	−2.287*	−0.355	−0.841	−1.445
Education	−0.053	−0.157	0.201	0.323*	−0.115
Depressive symptoms	0.322*	0.518***	−0.070	−0.067	0.290

Correlations were calculated to examine whether age, education and depressive symptoms related to pain and cognition. Mann-Whitney U tests were performed to examine possible associations of gender and analgesic medication with pain and cognition. Higher scores on the cognitive domains represent better performance. Gender was coded as follows: score 0 = male, score 1 = female.
*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

the only significant predictor of pain intensity ($R^2 = 0.225$, $\beta = 0.474$, $p < 0.01$). These results indicate that better executive function performance relates to an increasing level of self-reported pain. None of the other cognitive domains significantly predicted pain experience.

The results mentioned above were based on an average pain rating, collected on two different time moments. A pain rating at the time of testing might be necessary if one wishes to examine whether higher levels of pain, by demanding attention, reduce cognitive test performance. Therefore, the analyses were repeated with the primary pain ratings, which were obtained at the end of the testing session. Results, however, were completely comparable to previous findings: a single positive relationship was noted between pain intensity and executive functions.

Pain unpleasantness

With regard to pain unpleasantness, significant associations were found with depressive symptoms ($r = 0.518$, $p < 0.001$) and use of analgesics ($Z = -2.287$, $p < 0.05$). These two confounders, however, were not controlled for as they did not significantly relate to any of the cognitive domains. None of the other variables – age, gender or education – related to the affective-motivational components of pain.

A single significant correlation emerged between pain unpleasantness and executive functions ($r = 0.459$, $p < 0.01$), implying that better executive function performance is related to a higher level of self-reported pain unpleasantness. Again, memory ($r = -0.198$, $p = 0.22$) and processing speed ($r = -0.240$, $p = 0.13$) were not significantly related to pain unpleasantness. Executive function entered as the only significant predictor of pain unpleasantness ($R^2 = 0.211$, $\beta = 0.459$, $p < 0.01$) (see Figure 1). None of the other cognitive domains entered the analysis.

Similar observations were made when the analyses were restricted to the pain assessments obtained during the testing session.

Discussion

The present study focuses on the relationship between cognitive functioning and the experience of self-reported pain in residents of homes for the elderly with chronic pain. The results indicate that executive function performance predicted both pain intensity and pain unpleasantness ratings, implying that better executive function performance positively related to the reported severity of pain experience.

Executive function and pain experience

A priori two different mechanisms were postulated that could account for a possible relationship between pain experience and cognition. One focused on pain as a distracter which should theoretically result in an inverse relationship between pain experience and cognition (Karp *et al.*, 2006). The positive association that was observed between executive function and reported pain experience contradicts this prediction. However, this observation is in agreement with the second hypothesis, namely, that cognition as an indicator of changes in brain function positively predicts pain experience. Why should executive function but not memory or processing speed predict pain experience? An answer might be found by considering the profound role of the frontal lobes in both executive function tasks and pain processing. In patients with frontotemporal dementia, who suffer from severe frontal lobe degeneration, a decrease in awareness of painful stimuli has been reported (Bathgate *et al.*, 2001). Studies furthermore reveal a positive association between chronic pain experience and activation in the prefrontal lobes (Baliki *et al.*, 2006). This indicates

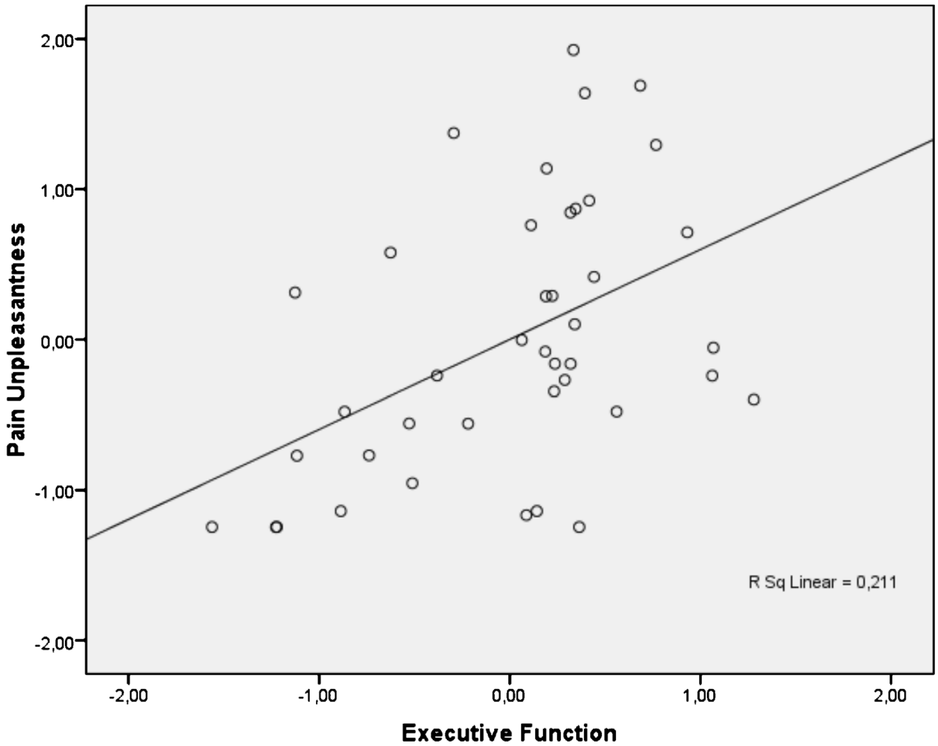

Figure 1. The relationship between executive functions and pain unpleasantness

that intact frontal lobe functioning might be extremely important for the conscious experience of pain. From this perspective, it seems likely that intact executive function performance positively relates to the severity of self-reported pain, as it reflects intact frontal lobe function and thereby awareness of pain. Also, considering the high sensitivity of executive functions to the effects of age-related changes in the brain, tasks measuring these functions may be the most sensitive indicators of these changes.

However, one point that warrants caution is the possibility that executive functions are not related to the *experience* of pain but actually relate to the ability to *report* pain or to use pain scales. If that is the case, a decrease in executive functions might result in under-reporting of pain compared to the actual pain experience. This suggestion is supported by a near significant *positive* correlation ($p = 0.066$) between reported depressive symptoms and executive functions (Table 2), implying that better executive functions relate to higher levels of reported depressive symptoms. This possibility is extremely important when one considers the high prevalence of painful conditions in the elderly and the reported reduction in pain treatment that parallels the level of cognitive decline (e.g. Won *et al.*, 1999).

Another point of caution concerns the presumed relationship between the prefrontal cortex and experience of pain in the present study. As no neuroimaging was performed, this relationship remains speculative. Other factors might actually mediate the relationship between pain experience and executive functions in the current study, such as the level of physical activity. A positive relationship between level of physical activity and executive functions has been reported (Bixby *et al.*, 2007). More physical activity might induce more pain and therefore mediate the relationship between better executive function performance and an increase in pain experience.

Pain intensity versus pain unpleasantness

The expected difference between the two different aspects of pain in relation to cognition was not confirmed; executive functions predicted both pain intensity and pain unpleasantness to a similar degree. A possible explanation for this observation brings into question the separability of the sensory-discriminative and affective-motivational components of pain assessed with pain scales such as employed in the present study. It can be argued that when using scales of pain intensity, such as the FPS, an affective component cannot be ruled out (Herr *et al.*, 1998). Specifically in chronic pain patients, the long duration of pain might result in a strong association between aspects of intensity and unpleasantness. In other words, it can be argued that the intensity of chronic pain becomes intertwined with the affective experience of pain. Alternatively, these results could also be due to a decrease in the ability to report pain, as a result of diminished executive function.

Strengths and limitations

Strengths of the present study include taking into account several factors known to influence both cognitive performance and pain experience, such as age and depressive symptoms. Secondly, the assessment of pain ratings was accomplished twice, reducing the risk of distorted pain measurements as a result of instantaneous pain.

One potential limitation of the present study is that no experimental pain stimulus was applied. This might provide more insight into whether either the *experience* or the *reporting* of pain is related to cognition. Also, the study sample was relatively small; this could account for not finding a significant association between pain and memory and between pain and processing speed. Nonetheless, the significant effects noted for executive function imply that it is unlikely that the small sample sizes are fully responsible for the current observations.

Conclusion

The present study indicates that executive function positively relates to self-reported pain experience in residents with chronic pain, which may reflect a positive relationship between brain functioning and conscious experience of pain. However, alternative explanations, such as a reduced ability to report pain or a mediating role of physical activity, cannot be ruled out. Further research should be undertaken in order to clarify the relationship between pain and cognition.

Conflict of interest

None.

Description of authors' roles

Joukje M. Oosterman was involved in study concept and design, subject and data acquisition, analysis and interpretation of the data, and preparation of the manuscript. Kerst de Vries was involved in subject acquisition and preparation of the manuscript. Chris Dijkerman and Edward de Haan were involved in preparation of the manuscript. Erik J.A. Scherder was involved in study concept and design, and preparation of the manuscript.

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